



 Research Article

Researching the Properties of Cotton Fiber

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ABSTRACT

The article discusses the properties of the fiber, which are the factors that determine the quality and properties of the yarn. Cotton fiber-whose physical properties vary by region, is still a very prevalent fiber used in the textile industry. Properties such as length, fineness, uniformity and hairiness, fiber strength and maturity affect the strength of the yarn. In this scientific study, four different blends were used as raw materials - cotton (Selection varieties: "Andijan-35", "Porlok-2", "S-6524", "Bukhoro-6"), which were spun into compact Ne 20 separately. The AFIS fiber properties are decisive factors for each type of blend, from opening, cleaning and up to the 2nd pass of the draw frame, for the yarn processing and spinning equipment steps. In addition, the tests carried out by USTER have confirmed the opinion that the parameters; unevenness, tenacity, yarn flaws, and hairiness of yarns made from different cotton blends are statistically different.

KEYWORDS

Selection cotton, cotton fiber properties, compact yarn properties, short fiber, spinning index (SCI), spinning process, neps, defects.

INTRODUCTION

Despite the decline in the share of cotton fiber in the world market, cotton fiber is still one of the most important natural raw materials with high demand and consumption. Industry scientists and cotton growers need to better study and analyze the following key issues that determine the quality of cotton fiber: fiber length, degree of ripeness (micronaire), impurity indicators, degree of stickiness, short fiber content (SFC), seed husk particles (SCNep) and nodule content (Neps).

Uster Statistics analysis for 2021 shows that the Neps value in cotton fiber is one of the most important quality indicators of cotton fiber, and it is also one of the main indicators for determining the efficiency of product quality in the ginning and carding processes, and even for assessing fabric quality.

HVI and AFIS measurement systems are commonly used to assess the quality of cotton fiber. The HVI (High Volume Instrument) system is designed to measure the fiber properties of a 10 g fiber sample, while the AFIS system is designed to determine the quality parameters of 1 g fibers. The main HVI measurements include fiber length, color indicators, micronizer index, and the presence of impurities in the composition, while the AFIS system measures fiber length, ripeness level, the amount of short fibers in the composition, the amount of ripe and unripe fibers, the number of knots in the sample, and the percentage of dust and impurities.

There is a strong correlation between the quality of the raw material and the final product. High quality cotton ensures high quality yarn regardless of the processing conditions. Cotton is exposed to many influences (mechanical, aerodynamic, etc.) during the processing processes, from harvesting to the final product. All of these processes affect the properties of cotton fiber, as well as the properties of yarn. In

the scientific research works and literature of foreign scientists, as well as Uzbek scientists, one can find many studies on the analysis of fiber properties by assessing the effect of each fiber property on the overall properties of the yarn.

The International Textile Manufacturers' Committee and the International Cotton Testing Federation (ITMF, ICCTM) reports indicate that the fiber knots (Neps), short fiber content (SFC), dust and dirt impurities, degree of maturity and degree of stickiness are important fiber parameters. The effect of Neps (fiber knots) on fiber quality is particularly noted as the most influential (negative) fiber property.

The aim of this study is to study the effect of the fiber mixture on the properties of quality yarn processed using equipment, such as uniformity (U%), strength (Rkm), defects (IPI) and hairiness (H).

The first part of the study consists of an analysis of the change in fiber value in the AFIS system during the yarn processing stages, and the second part is a statistical evaluation of fiber and yarn properties.

METHODS

Samples were produced from four different mixtures of 100% cotton (№1 "Andijan-35", №2 "Porloq-2", №3 "S-6524", №4 "Bukhara-6") selected as raw materials. All samples were tested in laboratory conditions, at a relative humidity of $65 \pm 4\%$ and a temperature of $20 \pm 2^\circ\text{C}$.

Yarn production was carried out using a series of production equipment for yarn processing at "URG TEX" Limited Liability Company. Cotton fibers were initially subjected to step-by-step mixing and cleaning processes on BOA, SP-MF, CL-P, MX-U, CL-U equipment from TRÜTZSCHLER (Germany). After mixing and cleaning, the carding process was carried out on a TC 15 carding machine and carding slivers were obtained. It is known that short fibers and tangled fibers that

cannot be carded are discarded during the carding process. To improve the parallelization, straightening and carding processes of the fibers, the slivers are combined in a sliver combining machine (Trutzschler TD9, Germany) after carding. The slivers from the first pass of carding

were transferred to the second pass of the TD10 carding machine, then the slivers were reprocessed in a Zinser 5A carding machine (Germany) to form slivers, and then spun into yarn on a Zinser 72 Impact XL spinning machine.

Table 1

Indicator name	Parameters
Bed extension, g/m	500
Number of rotations of the receiving drum, daq ⁻¹	1250
Number of revolutions of the main drum, daq ⁻¹	520
Hat speed, mm/daq	320
Output speed, m/daq	200
Number of hats in the process	99
Cleaning devices between the main drum and the caps (from back to front in five positions)	1:0,250 situation
	2:0,250 situation
	3:0,220 situation
	4:0,220 situation
	5:0,200 situation

Table 1 presents the technological process of the cotton fiber samples in the carding machine, and Table 2 presents data on the main technological

parameters of the spinning process sequence. In each technological process, the indicators of the semi-finished sliver, sliver, and finished 20-tex yarn product of cotton fiber are shown.

Table 2

Name	Parameters
	T – 20 teks
Linear density of the pile, k/tex	5,15
Pile 1 pass TD 9	8
Pile 2 passes TD 10	6
Linear density of the pile, tex	740
Number of twists of the pile, kr/m	44
Rotation frequency, min-1	18000
Number of twists on the yarn, min-1	780
Zinser 72 Impact XL tool system	3*3 Compact

Spinning	37,5
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Measuring fiber and yarn properties.

Each group of cotton fiber samples in the blend was tested on AFIS PRO and HVI 1000 laboratory equipment. The changes in fiber properties (e.g. micronizer, spinnability index, SCI values, tenacity, etc.) along the passes during fiber processing were studied. Yarn quality parameters were evaluated on the Uster Tenso-Jet 5 (Switzerland) testing equipment, and tests for

unevenness and hairiness levels were performed on the Uster Tester 5 (Switzerland) testing machine.

The spinnability index (SCI) is one of the most important indicators obtained on HVI instruments, providing information about the fiber quality and yarn elasticity:

The SCI regression equation is determined using the formula:

$$SCI = -414,67 + 2,9Str - 9,32Mic + 49,17UHML + 4,74UI + 0,65Rd + 0,36(+b), \quad (1)$$

where: SCI - fiber spinning coefficient; Str - fiber strength; Mic - fiber micron index; UHML - upper average length per inch; UI - uniformity index; Rd - light reflectance; (+b) - yellowness index of cotton fibers.

Short fiber index (SFI) is one of the most important indicators for predicting yarn quality.

SFI is estimated using the HVI measurement values for length and uniformity index, as shown in equation (2).

Previously, SFI was calculated as the first-order optical fiber interweaving indices of 2.5% SL and 50% SL:

$$Z = 384,3966 - 120,379X - 6,7003Y + 12,4901X \cdot 2 + 0,02957Y \cdot 2 + 1,0306XY, \quad (2)$$

where: Z is the short fiber content value (SFI); X is the fiber length according to HVI; Y is the uniformity index.

Neps is one of the main indicators of cotton fiber, which is formed as a result of foreign matter and entangled short and dead fibers in the cotton mixture. The presence of neps in the mixture leads to a decrease in yarn strength, the appearance of thick spots, which leads to a deterioration in the quality of the fabric and an uneven appearance.

The quality indicators of the yarn are usually determined by the properties of the fiber in it and the number of knots in it. Uster Technologies provides a brief classification of the composition

of defects for medium-fiber cotton fiber (Uster Technologies neps number classification) determined using the indicators of the AFIS system in Table 3.

To study the changes in fiber properties during spinning passes, samples were taken after each pass of the spinning machine: Blendomat BOA, SP-MF, CL-P, MIX-U, SF-C, Direct Feed, condenser 1, carding machine, first pass of the carding machine, second pass of the carding machine, and on the cards. The fiber cotton blend and carding samples were then tested in the AFIS system to assess the effect of the machine on fiber properties.

Table 3

Total number of knots (neps), pcs/g	Seed husk and fiber, pcs/g	The amount of fiber in the tubers.
<100	<10	very low
101...200	11...20	Low
201...300	21...30	medium
301...450	31...45	high
>451	>46	very high

15 random samples were selected from each fiber blend and the results were averaged in the AFIS

system and presented in Table 4 (Quality indicators of cotton fiber blend (AFIS data)).

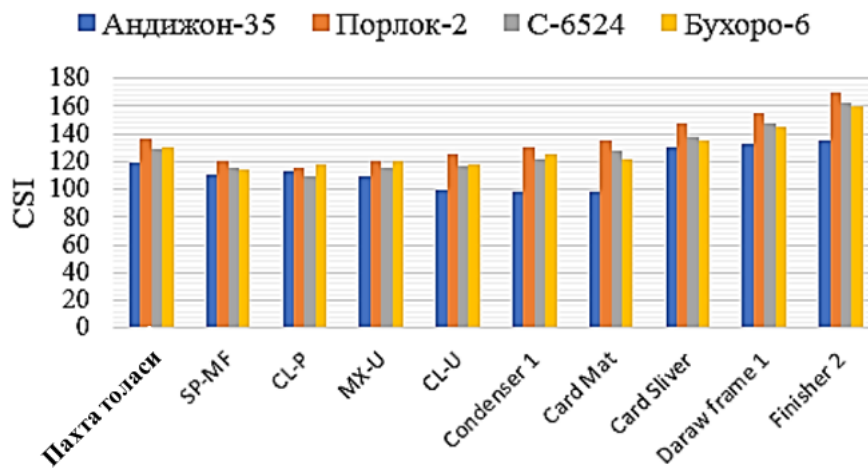
Table 4

Indicators		SCI	Total Nep Cnt [Cnt/g]	Fiber Nep Cnt [Cnt/g]	SCNep Count [Cnt/g]	SFC (w) % 0.5in	5% L(n) [in]	Fines [mtex]	Maturity Ratio
Uster Statistiks-2018	5%	180	103	97	4.7	2.8	33/34	177	0.96
	25%	163	160	151	8.7	4.3	33/34	170	0.92
	50%	130	237	224	13	5.7	33/34	162	0.89
№1 (Andijon-35)		119	302	277	25	10.4	33.5	192	0.82
№2 (Porloq-2)		136	198	185	13	5.3	35.3	177	0.91
№3 (S-6524)		129	239	220	19	7.2	33.8	169	0.87
№4 (Buxoro-6)		131	232	212	20	6.8	34.6	165	0.89
Ko'rsatkichlar		MIC	UQL (mm)	UI	ML (mm)	Strcn/tex	Rd	IFC (%)	UR (%)

№1 Andijon-35)	4.96	28.2	79.65	23.6	27.5	76.52	5.7	46.5
№2 (Porloq-2)	4.48	31.2	83.11	25.2	30.26	80.1	4.8	50.0
№3(S-6524)	4.75	28.8	80.21	24.3	28.54	78.85	4.9	47.6
№4 (Buxoro-6)	4.66	29.1	81.42	24.8	29.95	79.46	6.0	48.8

From Table 4, it is possible to determine the SFC values, which indicate the proportion of fibers with a length of 0.5 inches (12.7 mm). The composition of the mixture No. 1 has the maximum value, and the SFC value with the minimum value is obtained for the composition of the mixture No. 2. It was also noted that the main

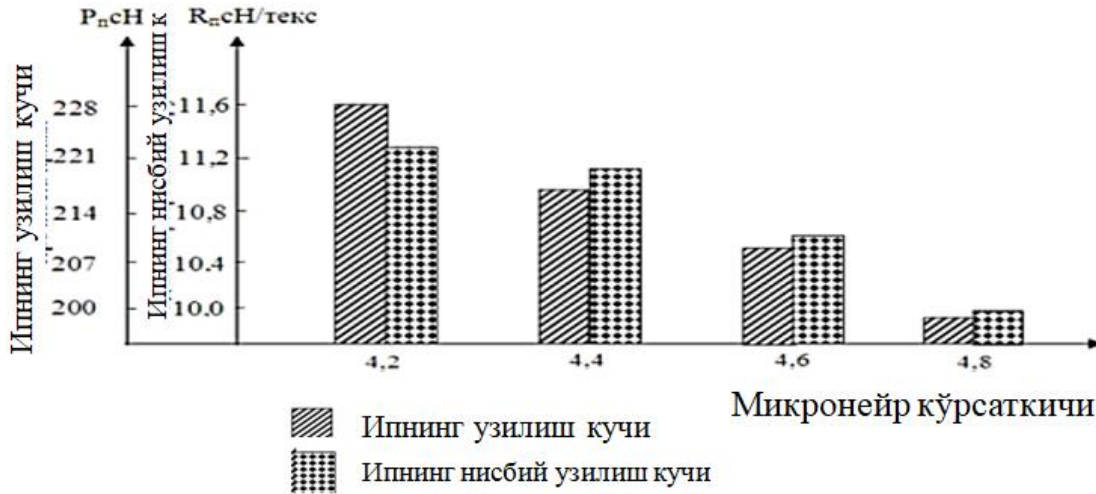
values of SFC(n) for the combed fiber vary from 4...12%. It is difficult to remove short fibers, knots during spinning and carding. To remove them, moderate carding is required, which can ultimately lead to an increase in waste and a decrease in product yield, as well as a negative effect on the quality of the yarn in terms of unevenness and relative tenacity (Rkm).



1 picture.

Figure 1 shows the SCI values for all cotton blends in the runs. The SCI values vary over a range for each blend and do not change dramatically until the carding process. The carding process improves blend #2, increasing the SCI from 133 to 150 and blend #4 from 128 to 143, while the other two blends do not. The improvement in SCI

is achieved by systematically removing short fibers from the blend. After the carding process, the rest of the processing equipment helps to improve the overall SCI for each of the four blends. At the end of the second run, blend #2 has the highest SCI value, followed by blends #3, #4, and #1 in order.



2 Picture.

Generally, the lower the linear density of the fiber, the higher the coarseness and the lower the unevenness of the yarn. Thus, a small micronizer value leads to an improvement in the quality of the yarn (Figure 2 - Effect of micronizer

properties on yarn tenacity (PcN) and specific breaking strength (Rkm), (cN/tex)). The relationship between the micronizer value and the linear density of the fiber is expressed by the following formula:

$$T = \frac{Mic}{25,4} \cdot 1000, \quad (3),$$

where: T - linear density of the fiber, mtex; Mic - fiber micronizer index.

When developing, it is necessary to take into account the effect of cotton fiber micronizer indices on the properties of the yarn. A high micronizer index in cotton fiber yarns leads to a decrease in the number of fibers in the yarn,

which affects the deterioration of the quality of the yarn in subsequent passes.

The number of fibers in the cross section of the yarn can be determined by the following formula proposed by SITRA (India):

$$n = \frac{5315}{Mic \cdot 0,354 \cdot Ne} \quad \text{va} \quad n = \frac{15000}{Mic \cdot Ne}$$

where: Mic is the micron of the fiber; Ne is the English yarn number; 5315 is the correction factor between the number systems.

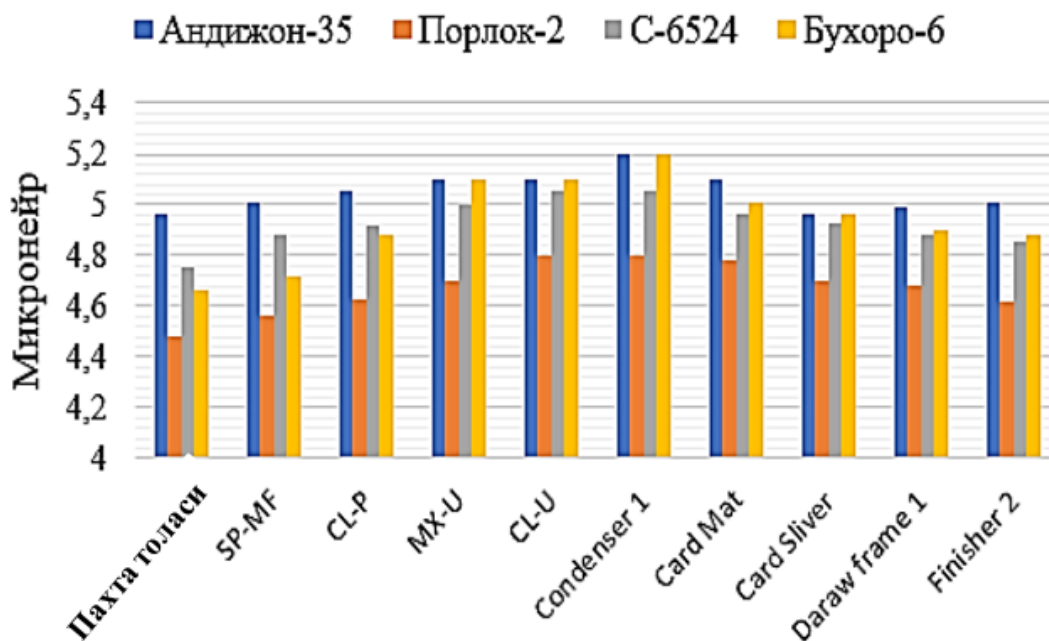
The degree of ripeness of cotton fiber is one of the most important indicators of yarn properties, and its determination is a very laborious process. This work can be carried out mainly in scientific

centers or institutions. Therefore, it is important to use the cotton fiber micron index based on alternative solutions in determining yarn properties. The experiment to determine the micron takes a few seconds.

The size of the micron of the fibers affects the change in the number of fibers in the cross section of the yarn. The basic value of the micron varies

from 3.2 to 5.9. The conducted analyses show that the fiber count composition of 119 to 140 (Mic in the range of 3.6...4.2) in the cross-section of a yarn with a linear density of 18.5 to 20.0 tex improves the physical and mechanical properties, reduces

yarn breakage during the spinning process, which increases the productivity of technological equipment.



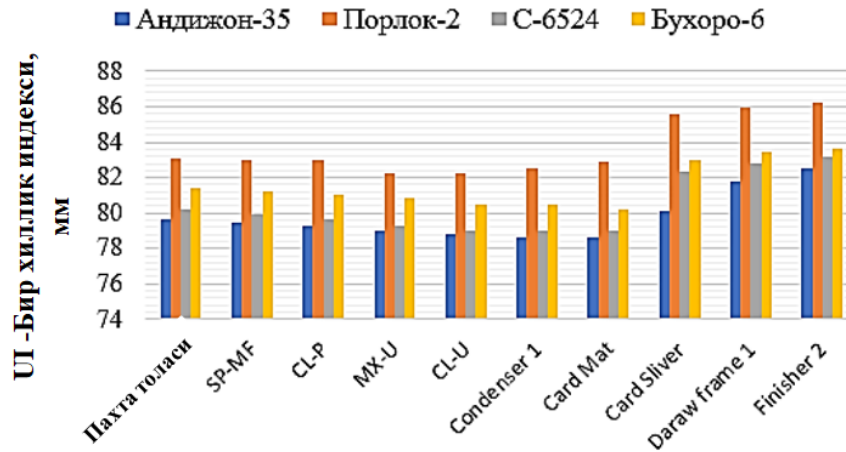
3 pictures.

Figure 3 shows the micron values of all cotton blends starting from the skein. Micron is one of the most important properties of the fiber, as this parameter directly affects the spinnability and strength of the yarn, as well as the properties of the fabric made from this yarn.

The carding process leads to a clear improvement in cotton blend #2, which has the lowest micron value of all four cotton fiber blends. The levels of micron in blends #1, #3 and #4 vary within a narrow range compared to blend #2. The micron value of blend #1 shows the largest increase due to the intensive removal of short fibers by the carding machine. The highest values in terms of micron are obtained from blends #1 and #4.

The uniformity index (UI) is the ratio between the average length (ML) and the upper average fiber length (UHML), and this indicator is expressed as a percentage. UI affects the Uster uniformity and yarn strength, as well as the efficiency of the spinning process. It also depends on the short fiber content (short fiber content less than 1/2 inch - SFC). Cotton with a low uniformity index may have a high percentage of short fibers. Such cotton is very difficult to process and can produce poor quality yarn.

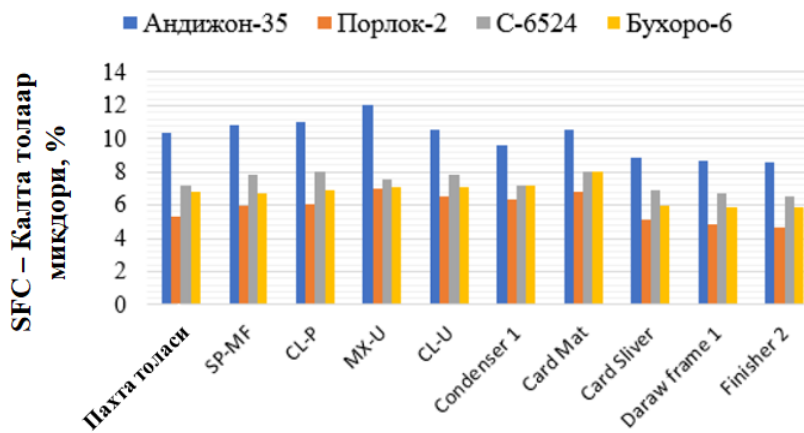
Figure 4 shows UI values for all types of cotton blends, from cotton rovings to second pass rovings and yarn.



4 pictures.

UI values show some fluctuations until the first pass of the carding machine, after which there is a general trend towards increasing UI values. The

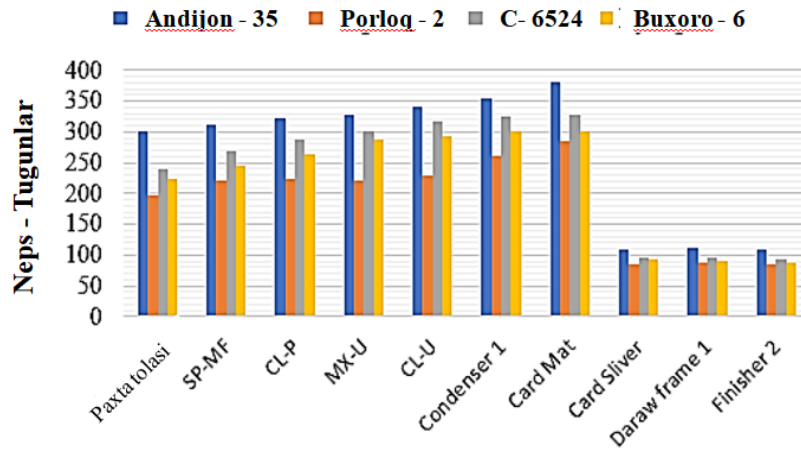
carding process leads to a clear improvement in cotton blend #1, which has the lowest UI (mm) value among all four cotton blends.



5 pictures.

The UI values of blends #2, #3 and #4 vary within a narrow range compared to blend #1. However, blend #2 shows a significant advantage. Figure 5 shows the short fiber content (SFC) values from the tow to the yarn for all cotton blends. These short fibers directly affect the

carding wick unevenness [U%] and the resulting product. At the optimum take-up rate, the short fibers are removed by the carding machine using the slivers, which in turn can improve the yarn U%.



6 pictures.

The cotton and fiber blend No. 1 has the highest SFC values across all process steps. The carding process leads to a clear improvement in the SFC values for the cotton fiber blend No. 2. The highest SFC value was obtained for the blend No. 1 at the end of the second pass of the carding machine.

The initial processing of cotton fiber in the mixing and cleaning section leads to an increase in the number of neps, which can be attributed to external mechanical factors associated with the working bodies of the machines acting on the fiber, as well as to the pneumatic transport of the fiber through the process steps. During the mixing and cleaning processes of the fibers, the number of knots increases and the fibers become shorter. This can be explained by the fact that during the mixing and cleaning process, the fibers are exposed to the action of the pile and needle drums, which leads to the crushing of large impurities, as well as the formation of knots in the fibers. Thus, defects appear.

These knots can cause major problems in the finished yarn, which leads to an increase in the IPI value. The IPI criterion is the total number of yarn defects, an indicator of the total amount; thick, thin areas and knots (neps) of a 1000-meter length of yarn. The IPI values for yarn are: thick

dots (+50%) - thick parts, thin dots (-50%) - thin parts, knots - Neps (+200%).

According to Figure 6, the minimum amount of neps belongs to the mixture No. 2, and the maximum number of neps is shown in the mixture No. 1. At the same time, in the second pass of the carding machines, the largest number of neps was obtained in the mixture No. 2, followed by the mixtures No. 3, No. 4 and No. 1 in sequence.

CONCLUSIONS

For the Republic of Uzbekistan, cotton fiber is considered a strategically valuable commodity and is not exported. Over the past 10 years, the micronymer index of cotton fiber grown has been overestimated - from 4.6 to 5.0, which makes it difficult to transition to a qualitative increase in spinning production. This phenomenon is observed all over the world and requires the creation of new cotton selection varieties. The new varieties of cotton fiber "Porloq-1", "Porloq-2" can meet the criteria required for cotton spinning today. Today, "Porloq" is the only genetically created variety of agricultural plants, which has unique quality characteristics, giving a

fine fiber value (low micronmer, Mic) and long fibers with high strength.

To plan the quality parameters of yarn, it is necessary to take into account two factors that directly affect the quality of yarn: the properties of the fiber and their changes in the transitions, as well as the filling parameters of the technological equipment.

The use of new technology in the spinning process does not mean that we will achieve a quality product. When using outdated technological equipment during the transition period and introducing new, advanced equipment, it is necessary to take into account the optimization of the parameters of the working bodies of the machines for the new selection varieties of cotton fiber “Porloq-1” and “Porloq-2”.

The results of our research show the influence of the properties of various cotton blends on the properties of yarn.

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